Table 1. Age in subjects' group (mean ± standard deviation).

Group	Age (yr. old)
Young	21.4 ± 4.1
Middle-aged	49.5 ± 6.3
Elderly	69.3 ± 5.6

was constructed.

2. Model and Evaluation

The subjects with no past medical history of diseases of the ear or nervous system were voluntarily participated in this study. A subject belongs to one of three groups (young, middle-aged, and elderly) that consist nineteen healthy persons (Table 1). The experiment was sufficiently explained to the subjects and written consent was obtained before the experiment.

Stabilometry was performed while viewing 2D/3D video clips. Gravicorder GS3000 (Anima Corp., Tokyo) was used as a stabilometer. The sampling frequency was set to be 20 Hz. Using Smart-Glass BT-200 (EPSON, Tokyo), the subjects watched four kinds of 2D/3D video clips that were reconstructed from Sky Crystal (Olympus Memory Works Corp., Tokyo) with approval by the company (Fig. 1). In this experiment, one of video clips was presented to the subjects during the test with their eyes open. The body sway was continuously measured for one minute with eyes open and for the next one 1 minute with eyes closed. The measurement was performed in Romberg's posture, and the order of video clips was randomized in consideration of the influence of the order effect. In order to exclude external stimulation other than the video clip, a blackout curtain was set in front of the subject so that we can remove visual influence through the Smart-Glass.

The x-y coordinates of center-of-pressure (COP) were recorded at each sampling time in both tests with eyes open/closed. Based on the equations established by the Japan Society for Equilibrium Research, analytical indices for stabilograms: the area of sway, total locus length, and total locus length per unit area, were calculated from time series of the COP in the x- (right direction was regarded as positive) and y- (forward direction was regarded as positive) directions for each test as well as previous studies. We also calculated the sparse density (SPD), which is a parameter proposed by Takada *et al.* (2003), and it is said that the SPD can evaluate stability of the posture. The parameters are defined as follows:

2.1 Total locus length per unit area

A value obtained from the calculation, dividing the total locus length Xr by the area of sway Yr. A decrease in the value indicates the instability of the posture.

2.2 Sparse density (SPD)

The SPD is defined by an average of the ratio $G_j(1)/G_j(k)$ for $j = 3, 4, \ldots, 20$, where $G_j(k)$ is the number of divisions having more than k measured points. A stabilogram is divided into quadrants whose latus is j times longer than the resolution. If the center of gravity is stationary, the SPD value is 1. If there are variations in the stabilograms, the SPD value is greater than 1. Thus, the SPD depends on the characteristics of the stabilogram and the minimal structure of the time-average potential function.

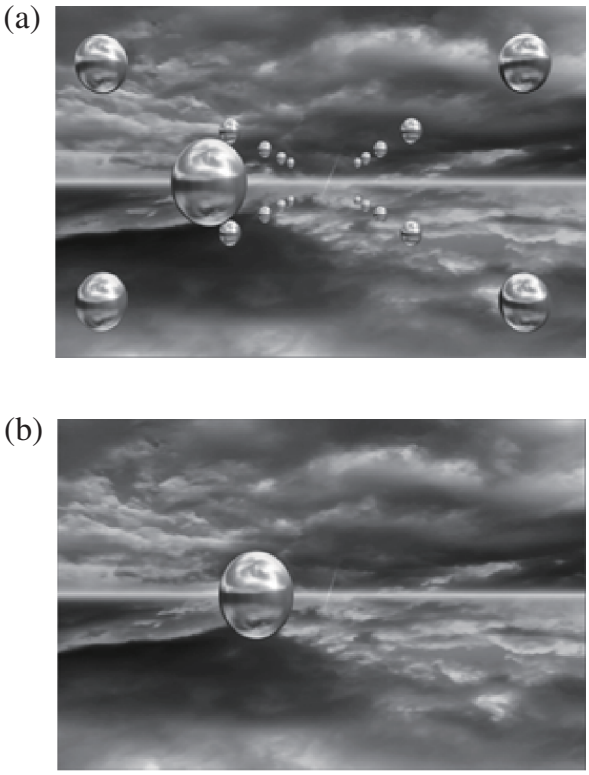

Fig. 1. Spheres are fixed at the 4 corners, giving perspective clues, and another sphere moves on the screen in a complex way (a). An image extracted from a video clip without spheres at the 4 corners, giving no perspective clue (b).

Spheres were fixed at the 4 corners in the 2D/3D video clips with perspective clues. 2D/3D video clips with/without perspective clues were presented in a random order, and the above-mentioned sway values were calculated from the stabilograms. Age, solidity of the subjects' vision (2D/3D) and the presence of perspective clues were assumed to be important factors, on which a two-way analysis of variance (ANOVA) was conducted for the number of repetitions 19. In addition, the two-way ANOVA for each sway value was followed by multiple comparison (Nemenyi test). In this paper, the significance level was set at $p = 0.05$.

Stabilograms were measured while viewing video clips; 2D A, 2D B, 3D A, and 3D B that were corresponding to a 2D video clip with perspective clues, a 2D without perspective clues, a 3D with perspective clues, and a 3D without the clues, respectively (Fig. 2). There was no significant interaction between any couple of factors and no significant main effect for each-aged group with eyes open/closed.

In the elderly subjects (Fig. 2), total locus length, area of sway, and the SPD while viewing the 3D video clip without the perspective clues were significantly greater than those while viewing the 2D ($p < 0.05$). The area of sway while/after viewing the 3D without the perspective clues was significantly greater that those while/after viewing the